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BRAIN CONTROLLED WHEELCHAIR FOR DISABLED

ANUPAMA H. S[1], N. K. CAUVERY[2] & LINGARAJU G. M[3]

[1]Department of Computer Science and Engineering, R. V. College of Engineering, Bangalore, Karnataka, India

[2]Department of Information Science and Engineering, R. V. College of Engineering, Bangalore, Karnataka, India

[3]Department of Information Science, M. S. Ramaiah Institute of Technology, Bangalore, Karnataka, India

ABSTRACT

Every physical move we make is triggered by neural processes in the brain. With the right equipment and recent developments in both brain imaging technologies and cognitive neuroscience, it is possible to read and record these processes. This has led to the rapidly growing field of brain computer interfaces (BCI). The Brain Computer Interface (BCI) helps unblessed people to make use of the devices and applications through their mental activities. So people believe that BCI technology is a blessing for the unblessed persons who may be suffering from severe neuromuscular disorders. So in this paper, we develop a cost effective Brain Computer Interface device to control the wheel chair for physically disabled people. The EEG analysis concept has been utilized to drive an electric wheelchair system automatically for quadriplegics or immobile persons. The EEG signals are captured from user's brain activity using "Neuro-sky Mind wave" EEG sensor which is placed on the user's forehead. The EEG signals that are generated at different level of concentration, also the eye movement artifacts in the EEG are processed using Lab VIEW software by means of FFT algorithms. The direction on which wheel-chair has to move is decided based on the processed EEG signal. Microcontroller MSP430G2231 controls the motor circuitry to drive the wheel chair in a Non-jerky manner.

KEYWORDS: BCI, EEG, FFT, Lab VIEW –Laboratory Virtual Instrument, Microcontroller

INTRODUCTION

The Human Computer Interface (HCI) is an interdisciplinary field of knowledge and Brain Computer Interface (BCI) is its subfield [9]. The BCI device acquire signals from a subject's brain, extract their thoughts from the acquired signals and these signals will determine the intention of the subject and also what that subject is thinking. In order to develop the computer systems with good and maximum usability and interactivity, extensive research work has been done using human bio-signals. [10]. These human bio-signals can be acquired from nervous system.

The recording and analyzing of EEG (Electro-Encephalogram) signals are done by Brain Computer Interface. Some diseases or injury of a person/subject can result in complete loss of muscle control and /or movement despite the subject being fully conscious or aware of his/her surroundings. Recent advancements in brain-computer interfacing (BCI) have presented new opportunities for development of a new wheelchair interface for such patients based on thoughts. Considering these aspects this paper investigates a BCI design for brain-controlled wheelchair (BCW), which comprises three distinct stages: Signal acquisition that has a good quality signal, signal processing, knowledge discovery and classifying them into different control and interfacing to the powered wheelchair [11][14].

PROPOSED SYSTEM

The proposed system uses "Neuro-Sky Mindwave" headset or device to acquire EEG signals from human brain. The signals that are captured are fed into LABVIEW software for processing [4]. The acquired raw EEG signals from the headset are analyzed by making use of Virtual Instrumentation (VI) and Fourier Transformation (FFT) [12][15] technique suitable algorithm helps in deciphering these EEG signals [1]. For those signals which are deciphered text commands are generated using Lab VIEW VISA tool. Generated commands are then fed to MAX 232, which converts serial data to TTL logic. These level shifted signals are then converted to digital logic using MSP 430G2231 micro controller. This micro-controller helps in generating digital signals. Generated digital signals are fed to motor control circuitry. Based on these signals PWM signals are generated which decide the direction and speed of the wheel chair.

METHODOLOGY

The user's brain activity is sensed by Electro Encephalograph (EEG) device called "Neurosky Mind Wave" head-set. It consists of an electrode positioned in frontal position of the user scalp. The electric activity of brain is sensed by the electrode and the corresponding values are recorded. These signals are mapped at a rate of 512 SPS (samples per second). The recorded values are then transmitted in two ways, via USB cable and through Bluetooth. Analysis of this EEG signal is done using Lab VIEW software. It is possible to collect and store data from Neurosky Mind Wave head set and applying signal conditioning techniques to obtain the brain waves like beta waves(12-30Hz), alpha waves(8-12Hz), theta waves (5-7Hz) and delta (0.16-4Hz). These signals are analyzed in FFT power spectrum [2] [3]. A suitable algorithm is applied to identify the command for the wheel chair depending upon the attention and meditation level. The Lab VIEW software in the laptop, after performing the above process and identifying the command, generates corresponding data signal. This signal is level shifted using Max 232 IC to interface with microcontroller. The controller identifies the command and generates corresponding control signal, and sends it to motor control circuitry. Motor control circuitry initiates corresponding activity of the motor driven wheel chair. Thus the user is able to maneuver the wheel chair safely.

HARDWARE MODULE

- **NeuroSky Mind Wave Mobile Headset**

Figure 1: Neuro-Sky Headset

As the world's first comprehensive brainwave-reading device for iOS and Android platforms, the new Mind Wave Mobile headset is evolved for today's mobile user as shown in figure 1. It differs from Mind Wave by transferring data via Bluetooth, rather than radio frequency, and is available in two packages: Brainwave Starter Kit and the MyndPlay bundle.

- **USB- to -Serial Converter**

Figure 2: USB Converter

Few older devices use USB connectors, but most modern computers use this type of port to transfer data as shown in figure 2. By using a USB to serial adapter, you can continue to use your older serial-enabled device through your new computer's USB port. These cables are also referred to as USB to DB9 or USB to RS-232 cables. USB to serial adapters are cables that convert the data sent by a serial enabled device for use by a USB port. The serial end has a DB9 connector, which plugs into the serial device. The USB connector plugs into the computer's USB port or a connected USB hub. The data that are transmitted by the serial device are sent directly to the USB port, where it is passed to software to interpret it.

- **Level Shifting IC MAX 232**

The serial port on the computer complies with the RS-232 telecommunications standard. RS- 232 signals are similar to the microcontroller's serial signals in that they transmit one bit at a time, at a specific baud rate, with or without parity and/or stop bits. The two differ solely at a hardware level. By the RS-232 standard a logic high ('1') is represented by a negative voltage anywhere from -3 to -25V – while a logic low ('0') transmits a positive voltage that can be anywhere from +3 to +25V. On most PCs these signals swing from -13 to +13V**.**

- **Need for MAX232**

The MAX 232 is to connect a serial port device to a serial port which uses the RS232 standard. The serial port device is usually a UART, but that is often incorporated into a microprocessor chip. The RS232 standard specifies the voltage levels that represent the signaling and data lines in the interface. The standard is that the lines have source impedance around 300 ohms, the minimum voltage is +/- 6V, the maximum voltage is +/-22V, the minimum load is 3000 ohms and so on.

The logic states are therefore plus or minus 6V, and it is common to use plus/minus 12V. The logic level devices that create the RS232 signal work at 0 and +5V (in this case anyway). The MAX232 provides the interface, which involves a logic voltage inversion. It is two line drivers (outputs) that convert logic level to +/- RS232 and two line receivers (inputs) that receive +/- RS232 and convert then to logic level. The MAX232 is popular because it also generates the extra voltages for +/- 12V, using the +5V as a supply. There is no need for separate supplies just for this purpose. The voltage is generated by electronic switches which charge capacitors in parallel then discharge them in series.

- **Micro Controller MSP430G223**

The MSP430 is a very clean 16-bit byte-addressed processor with a 64K unified address space, and memory-mapped peripherals. The current family includes a variety of on-chip peripherals, and ranges from a 20-pin package with 1K of ROM and 128 bytes of RAM to 100-pin packages with 60K of ROM and 2K of RAM. Devices with greater RAM and ROM, and additional peripheral blocks are in development. The MSP430 excels where low power consumption is important. Many applications, such as water meters, are currently achieving more than 10 years operation from a single button cell battery. If low power is not critical, well, the MSP430 is a nice elegant device to use, anyway. It programs very well in C, making assembly language programming unnecessary. There is no memory bank switching to make the compiler's life difficult; it uses normal RAM for its stack; it has a clean 16 bit instruction set. In fact, it is somewhat like an ordinary desktop RISC processor, but requires very little power.

- **Prototype Model**

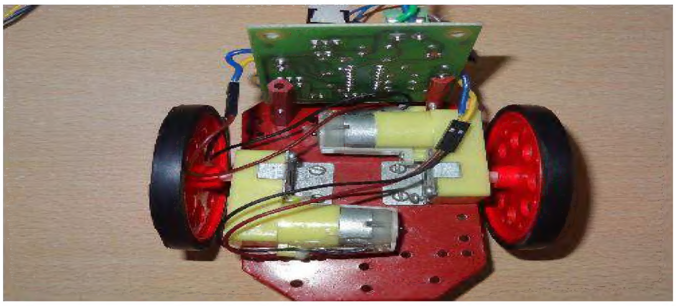


Figure 3: Wheel Chair Prototype

Figure 3 shows the prototype of the wheel-chair. It contains the two geared dc motors and wheel connected to the motor as shown in the figure. Driver drives these two motor and accordingly the wheel rotates based on the command given by the subject [7] [8].

FLOW CHART

- **Flow Chart for Initial Case Selection Process in Lab VIEW**

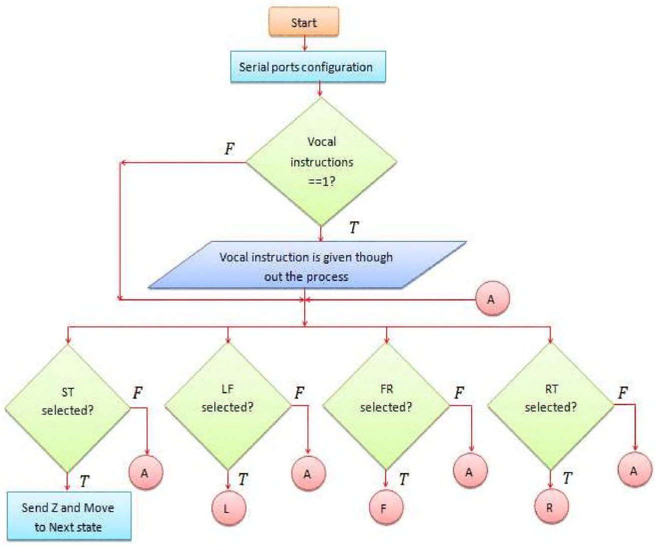


Figure 4: Initial Case Selection Process

- **Flow Chart for LEFT Movement**

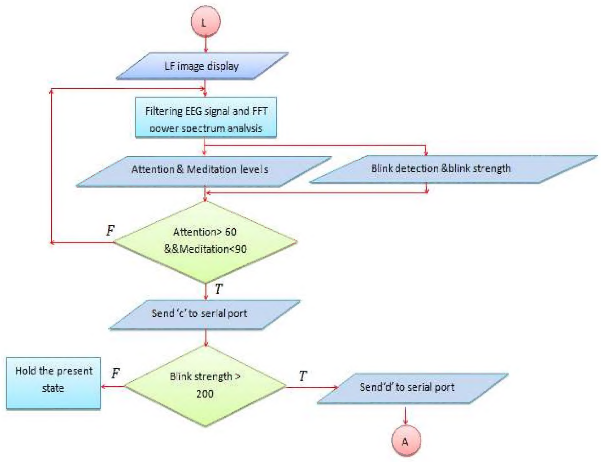


Figure 5: LEFT Movement

- **Flow Chart for FORWARD Movement**

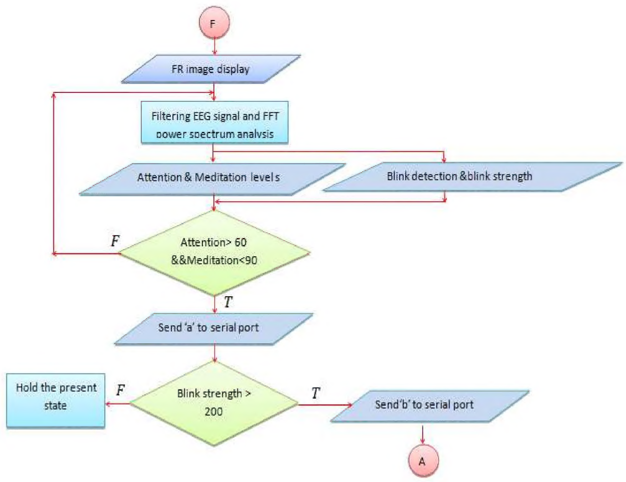


Figure 6: FORWARD Movement

- **Flow Chart for RIGHT Movement**

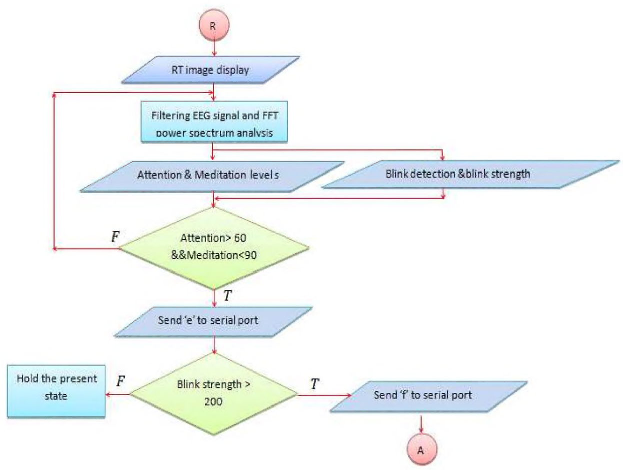


Figure 7: RIGHT Movement

- **Character Associated to Different Movement of Wheel-Chair**

Characters	PWM for motor control	Task
a	↑	FORWARD
b	↓	
c	↑	LEFT
d	↓	
e	↑	RIGHT
f	↓	
z	None	STATIONARY

Figure 8: Different Character and Related Motion of the Wheel-Chair

SOFTWARE MODULE

- **Program Description**

The LabVIEW controls the case selection, state machine, EEG signal processing and character generation for hardware operations of the system. The VI main program has several sub programs called SubVI"s, which performs some specific task and provides intermediate results required for the execution of main program [5]. The VI program has two parts (a) front panel and (b) block diagram. The front panel acts as the system display unit for the user. It indicates various system parameters to the user, so the user is able to understand and choose the required operation. The block diagram consists of graphical coding which performs various operations according to the user's input.

- **Initialization Process**

The Nuerosky mind wave EEG headset sensor is interfaced with the laptop via Bluetooth link to one of the COM ports of the laptop. The VI main program access the data sent to the COM port by the headset with function "Think Gear Create Task" which is used before initialization of any task related to headset. The COM port is assigned as the source file to the "Think Gear Create Task" function. This function clears any open connection at the COM port, and creates new connection with headset. Prior to the above process function "Think Gear Clear Connection" is used to disconnect any connectivity between headsets and any other program or device. The function "Think Gear Enable Blink Detection" is initiated to detect blink made by the user. The blink acts as an important response from the user for case selection in the program. Now the function "Think Gear Start Task" is initiated; this function starts the think gear tasks by establishing stable communication with the headset without any large delay. Thus pairing of headset and laptop takes place. Next function "Think Gear Signal Quality" is used to determine the signal quality available which is indicated on the front panel tab for the user.

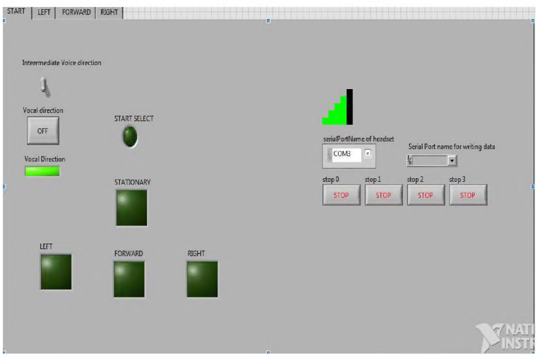
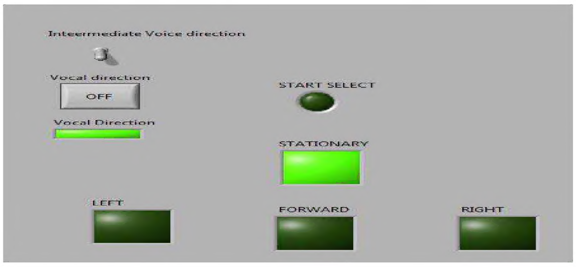


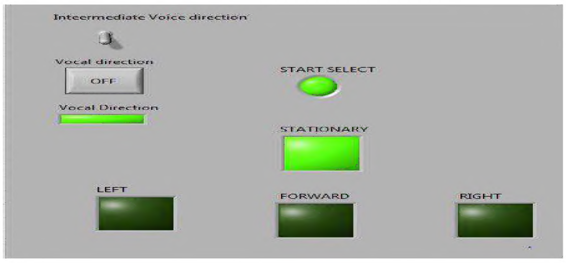
Figure 9: Main Tab Visible to Subject

- **Front Panel**

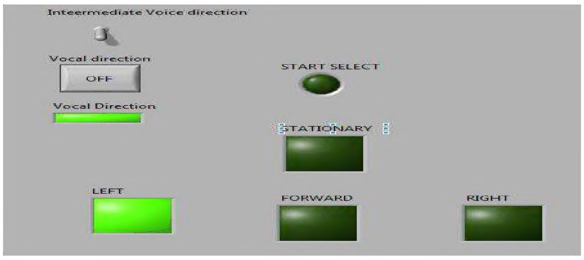
Here in this event the main tab is displayed to the user. This tab consists of four Boolean indicators namely STATIONERY, LEFT, FORWARD, RIGHT and START SELECT. Due to the implementation of state machine only one among STATIONERY or LEFT or FORWARD or RIGHT is highlighted for a certain time interval. When the START SELECT and any one of the required action is highlighted, the user has to blink for selection of that command. Thus user is able to select the required action and the respective TAB is opened in the front panel. The case which is selected is indicated by two string indicators present case and selected case. In parallel the initialization of the task for next process is started. It involves “Think Gear Create Task”, “Think Gear Clear Connection”, “Think Gear Enable Blink Detection”, and “Think Gear Start Task” functions performing the initialization process.



(a)



(b)



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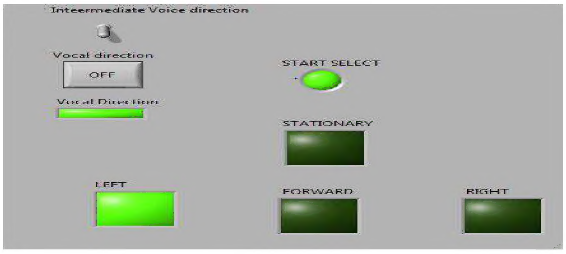
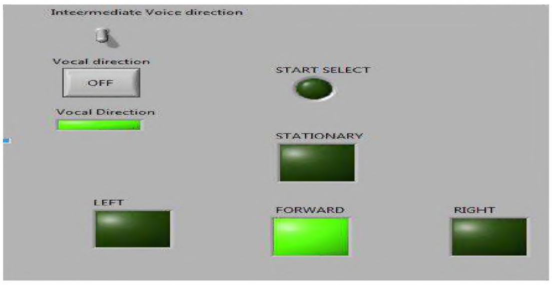
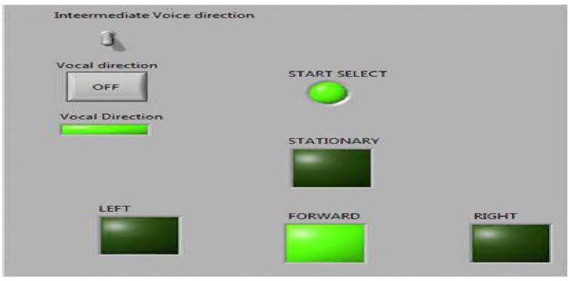


(d)

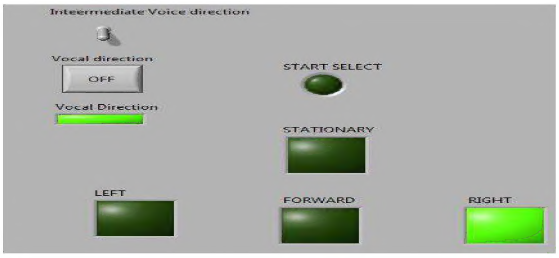
Figure 10: (a), (b), (c), (d) Different Cases of the STATIONARY and LEFT States



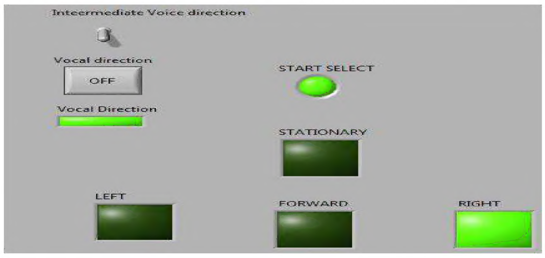
(e)



(f)



(g)



(h)

Figure 11: (e), (f), (g), (h) Different Cases of the FORWARD and RIGHT States

- **Block Diagram**

The state machine is implemented with the help of shift registers by sending in the case numbers in cyclic process. The SubVI "case_for_preselect.vi" highlights the corresponding indicator in the front panel according to the case input provided by shift register. The SubVI "case select.vi" is executed. This SubVI highlights the "START SELECT" indicator to indicate the user to blink if the case is to be selected. It also determines the blink strength with the help of „Think Gear Blink Strength" function. If the users blink strength attains threshold value, then the current case is selected and the execution of respective character generation block is initiated. If not, then default case in state machine i.e. "STATIONERY" is selected.

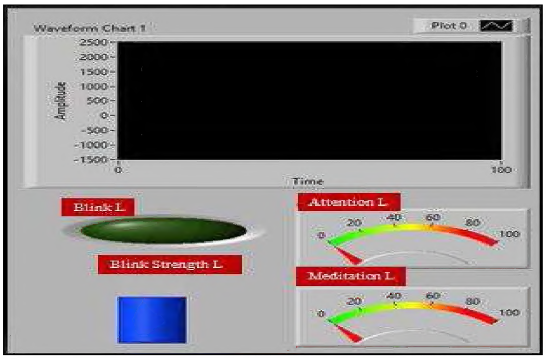


Figure 12: Processing and Output Indicating Virtual Instrumentation

RESULTS ANALYSIS

Right, Left, Forward and Stop commands given by the disabled person are deciphered using some algorithms and suitably executed. By selecting suitable IC's and circuit design, cost effectiveness of overall project is optimized. The training is been given to disabled user to generate the required thoughts which is needed to control the wheel chair movements. The speed of the wheel-chair is assumed to be of constant at a deadly low speed value to gain confidence of the quadriplegic subject. Wheel-chair's reverse movement is prohibited for safety reasons.

CONCLUSIONS

The EEG signals are acquired from Brain Computer Interface device and are processed using FFT spectrum and different cases of motion like Right, Left, Forward and Stop commands are deciphered distinctly on LabVIEW platform. For achieving better accuracy and reliability of both hardware & software, improvements in design are necessary. Character recognition and generating control codes are done efficiently by the microcontroller. Also, PWM based motors control for smooth movement of the wheel chair is an important feature, useful for quadriplegic users.

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